RISE-6G

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ISSUE OUTLINE

MESSAGE FROM THE COORDINATOR

The RISE-6G newsletters aim to highlight the project's objectives, technical achievements, and dissemination activities on a bi-annually basis.

The intended audience includes internal partners, but more importantly, all external interested parties, such as academics, researchers, industrial organisations, and legislation bodies.

This first issue contains an overview of the project, its objectives, structure, and technical approach, as well as a summary of its dissemination actions.

We warmly invite the readers to connect with us in our online presence platforms for more frequent and up-to-date content.

Dr. Emilio Calvanese Strinati
Project Coordinator
CEA-Leti

in
RISE–6G

www
https://rise-6g.eu/

PROJECT OVERVIEW

RISE-6G

BUDGET

€ 6.5 Million

100% EU-funded

CONSORTIUM

13 Partners

9 Countries

DURATION

36 Months

01/01/2021 - 31/12/2023

Abstract

Visions and plans on forthcoming 6G wireless networks have begun, aiming to provide flexible connect-compute technologies to support future innovative services and uses cases. Considering the 2030 horizon, 6G networks are intended to create the basis for human-centred smart societies and vertical industries. To this end, innovation is expected to: (a) support the long-term sustainable transformation of networks into a distributed smart connectivity infrastructure, where new terminal types are embedded in the daily environment; (b) provide the end-to-end connectivity-computation system with the higher flexibility and dynamism needed to accommodate the ever-evolving and heterogeneous nature of future applications, regulations, and specific user-/service-/location-based needs.

The RISE-6G vision capitalises on the latest advances on the technology of Reconfigurable Intelligent Surfaces (RISs) for radio wave propagation control, in order to substantially improve them and to conceive and implement intelligent, sustainable, and dynamically programmable wireless environments that go well beyond the 5G capabilities developed under the latest 3GPP standards.

The RISE-6G project will focus on: (i) the definition of novel network architectures and operation strategies incorporating multiple RISs, as well as (ii) the characterisation of their fundamental limits capitalising on our proposed realistic and validated radio wave propagation models; (iii) the design of solutions enabling the online trade between high-capacity connectivity, Energy Efficiency (EE), Electromagnetic Field (EMF) exposure, and localisation accuracy based on dynamically programmable wireless propagation environments, while accommodating specific legislation and regulation requirements on spectrum use, data protection, and EMF emission; and (iv) the prototyping-benchmarking of the proposed innovation via two complementary trials with verticals.

The project is poised to actively participate in standardisation bodies and bring its technically advanced vision into the planned industrial exploitation. This will secure the European technology leadership, supporting the creation of new European-conceived service and business opportunities in the 6G global race.

Technical Objectives

1. Fundamental research on RIS modelling and characterisation of the capacity limits of RIS-empowered smart radio environments.
2. Design, prototype, and trial radical RIS technologies with dynamic reconfiguration from sub6GHz to subTHz frequencies.
3. Beyond 5G low EMF emissions, increased localisation accuracy, boosted EE, and secrecy guarantees.
4. Minimal connect-compute network redesign and configuration costs.

Enhanced Connectivity

High Energy Efficiency

Low EMF Exposure

Improved Secrecy Rates

**Spatiotemporal Focusing**

Boosted Localisation

Ultra Reliability

SMART WIRELESS ENVIRONMENTS

The RIS Technology

- Refers to artificial surfaces comprised of hundreds or thousands of simple and ultra-low power circuitry elements with reconfigurable properties.
- Can be used flexibly to coat objects in the signal propagation environment, such as walls, mirrors, ceilings, or appliances.
- Performs as an anomalous reflector of impinging radio waves or as an analog processor of multipath scattering.
- Can play the role of a transmitter/receiver/sensor when equipped with relevant active radio-frequency elements.
- Supports a wide variety of functionalities:
  - Beamforming.
  - Range/position estimation.
  - Radio-frequency mapping/sensing.
  - Obstacles/activity detection.
  - Scattering enrichment.
- Particularly suitable for:
  - Limiting EMF exposure.
  - Controlling wave propagation and channel geometry.
  - Reducing the transmission power at existing base stations and access points.
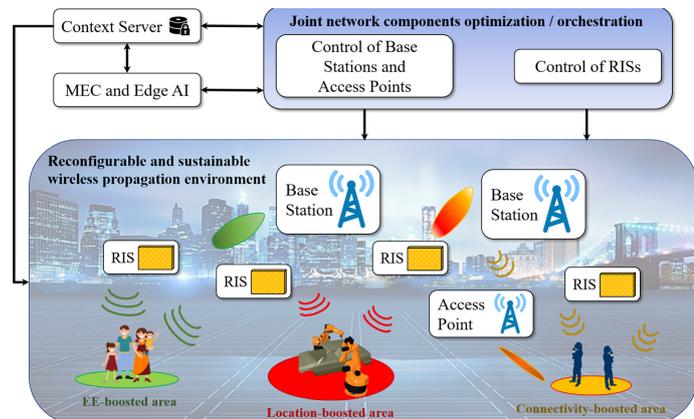
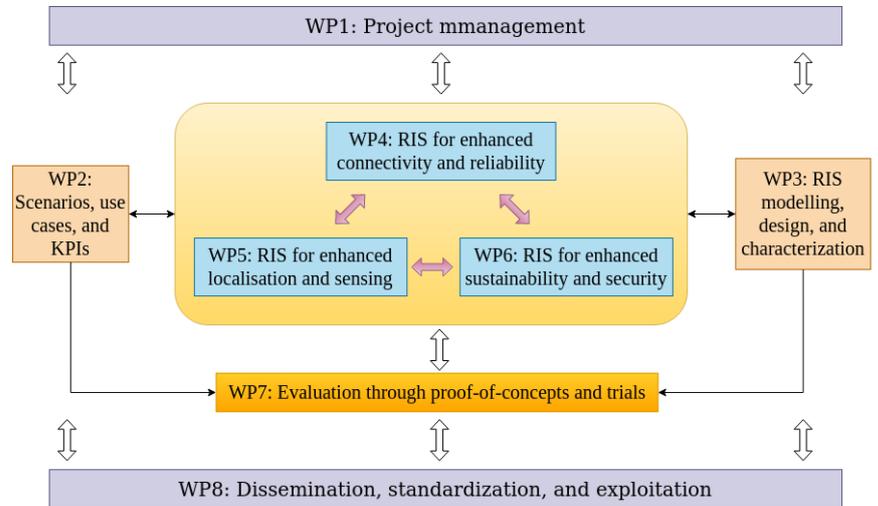## The Wireless Environment as a Service

The design and implementation of intelligent and sustainable environments will empower future wireless networks with capabilities that exceed those of current RIS solutions, and will thus lead to research and innovation breakthroughs.

In RISE-6G, we propose a novel wireless connectivity paradigm comprising of negligible-power RISs and conventional network nodes. This paradigm is aimed at jointly optimizing the radio wave propagation environment with the existing network infrastructure to realize highly concentrated (i.e., selective in time and space) service provisioning to intended end users, while removing energy from regions where accidental or unintended users are present .

The RISE-6G consortium proposes the novel concept of the **wireless environment as a service**, which offers dynamic wave propagation control for trading off high-capacity communications, increased EE and localization accuracy, as well as improved secrecy guarantees over eavesdroppers, while accommodating specific regulations on spectrum usage and restrained EMF emissions.

TECHNICAL APPROACH

The RISE-6G project is structured into 8 Work Packages (WPs), six of them (WP2-WP6) concern technical actions and the remaining two deal with the project management (WP1) and dissemination activities (WP8).

Technical Activities

WP2
- Definition of RIS-empowered use cases, scenarios, and relevant KPIs.
- Design of network architectures and deployment strategies for RISs.

WP3
- Modelling of RIS unit elements and RIS-empowered signal propagation.
- RIS hardware design, prototyping, and characterisation.
- Sounding of RIS-empowered wireless channels.

WP4
- Design of network architectures, control signaling protocols, and algorithms for enhanced connectivity with RISs.
- Fundamental limits and multi-user multi-RIS communications.
- Design of AI-enabled joint communication and (edge) computing services.

WP5
- Design of RIS-empowered network architectures, control strategies, and algorithms for localisation.
- Design of algorithms for RIS-enabled/RIS-boosted sensing (active or passive) and radio mapping.

WP6
- Design of architectures for RIS-empowered networks targeting EE-/low-EMF-/secrecy-boosted areas.
- Design and performance assessment of RIS optimisation algorithms for performance boosted areas.

WP7
- Validation of RIS functional components and integration.
- Field trial demonstration of RIS-enabled extreme coverage enhancement at the SNCF train station in Rennes, France.
- Field trial demonstration of RIS-enabled accurate indoor localisation at the Centre Richerche Fiat in Turin, Italy.

8
Work Packages

24
Tasks

35
Deliverables

7
Milestones

665
Person months

70 Publications

Submitted, accepted, or published at top journals and conferences

34 Dissemination Actions

Workshops, Special Sessions, Invited Talks, Tutorials, and more

Participation in Industry Standards

3GPP, ETSI RIS, ETSI MEC, O-RAN Alliance

PUBLICATION HIGHLIGHTS

RISE-6G

The first year of the RISE-6G project has produced more than 70 top-quality technical papers (available [here](#)), which are available on the project's website, including the inaugural papers with the project's vision and objectives in the 2021 EuCNC & 6G Summit and the IEEE Communications Magazine.

Wireless Environment as a Service Enabled by Reconfigurable Intelligent Surfaces: The RISE-6G Perspective

Emilio Calvanese Strinati[*], George C. Alexandropoulos[†], Vincenzo Sciancalepore[‡], Marco Di Renzo[§], Henk Wymeersch[¶], Dinh-Thuy Phan-huy[∥], Maurizio Crozzoli[**], Raffaele D'Errico [*], Elisabeth De Carvalho[††], Petar Popovski[††], Paolo Di Lorenzo[‡‡], Luca Bastianelli[‡‡], Mathieu Belouar[x], Julien Etienne Mascolo[xi], Gabriele Gradoni[xii], Sendy Phang[xii], Geoffroy Lerosey[xiii], Benoît Denis[*]

Abstract—**The design of 6th Generation (6G) wireless networks points towards flexible connect-and-compute technologies capable to support innovative services and use cases. Targeting the 2030 horizon, 6G networks are poised to pave the way for sustainable human-centered smart societies and vertical industries, such that wireless networks will be transformed into a distributed smart connectivity infrastructure, where new terminal types are embedded in the daily environment. In this context, the RISE-6G project aims at investigating innovative solutions that capitalize on the latest advances in the emerging technology of Reconfigurable Intelligent Surfaces (RISs), which offers dynamic and goal-oriented radio wave propagation control, enabling the concept of the *wireless environment as a service*. The project will focus on: *i*) the realistic modeling of RIS-assisted signal propagation, *ii*) the investigation of the fundamental limits of RIS-empowered wireless communications and sensing, and *iii*) the design of efficient algorithms for orchestrating networking RISs, in order to implement intelligent, sustainable, and dynamically programmable wireless environments enabling diverse services that go well beyond the 5G capabilities. RISE-6G will offer two unprecedented proof-of-concepts for realizing controlled wireless environments in near-future use cases.**

Reconfigurable, Intelligent, and Sustainable Wireless Environments for 6G Smart Connectivity

Emilio Calvanese Strinati, George C. Alexandropoulos, Henk Wymeersch, Benoît Denis, Vincenzo Sciancalepore, Raffaele D'Errico, Antonio Clemente, Dinh-Thuy Phan-Huy, Elisabeth De Carvalho, and Petar Popovski

ABSTRACT

Various visions of the forthcoming sixth generation (6G) networks point toward flexible connect-and-compute technologies to support future innovative services and the corresponding use cases. 6G should be able to accommodate ever evolving and heterogeneous applications, future regulations, and diverse user-, service-, and location-based requirements. A key element toward building smart and energy sustainable wireless systems beyond 5G is the reconfigurable intelligent surface (RIS), which offers programmable control and shaping of the wireless propagation environment. Capitalizing on this technology potential, in this article we introduce two new concepts: i) wireless environment as a service, which leverages a novel RIS-empowered networking paradigm to trade off diverse, and usually conflicting, connectivity objectives; and ii) performance-boosted areas enabled by RIS-based connectivity, representing competing service provisioning areas that are highly spatially and temporally focused. We discuss the key technological enablers and research challenges with the proposed networking paradigm, and highlight the potential profound role of RISs in the recent Open Radio Access Network architecture.

PROJECT MANAGEMENT

THE RISE-6G CONSORTIUM

RISE-6G

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- NEC LABORATORIES EUROPE GMBH **(NEC)**
- ORANGE SA **(ORA)**
- *TELECOM ITALIA SPA* **(TIM)**
- GREENERWAVE **(GNW)**
- CHALMERS UNIVERSITY OF TECHNOLOGY **(CHAL)**
- AALBORG UNIVERSITET **(AAU)**
- CENTRO RICERCHE FIAT S.C.P.A. **(CRF)**

- NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS **(NKUA)**
- CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE TELECOMUNICAZIONI **(CNIT)**
- CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE **(CNRS)**
- UNIVERSITY OF NOTTINGHAM **(UNOT**)
- SOCIETE NATIONALE DES CHEMINS DE FER FRANCAIS **(SNCF)**

HORIZON 2020